E/CONF.39/D/54
8 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: D.14

Hungary

BUILDING OF INDUSTRIAL PLANTS WITH SPECIAL ATTENTION TO PREFABRICATED ELEMENTS

By Dr. Jeno SZENDROI,
Planning and Designing Office
for Industrial Buildings "IPARTERV",
Budapest, Hungary

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

BUILLING OF INDUSTRIAL PLANTS
WITH SPECIAL ATTENTION TO PREFABRICATED ELEMENTS

by

Dr. Jenő SZENDRÓI
Planning and Designing Office for Industrial Buildings
"IPARTERV"
Budapest, Hungary

1./ Preambles of the prefabrication of reinforced concrete in Hungary.

a./ Following World War II. a speeded up industrialisation has been started in Hungary. Being primarily an agricultural country with insufficient heavy industry, there was little experience in the erection of industrial plants: forces for planning and building were few. We did not have enough basic materials of industrial investment, chiefly rolled steel and wood for the shutterings of monolithic reinforced concrete constructions. We had to omit the intermediary stages of industrial development, as observed elsewhere and the demands of a growing industry had to be met by immediate action.

b./ In these circumstances, the attention of Hungarian architects and engineers has been directed - perhaps for the first time in the history of architecture - towards precast reinforced concrete structures. We developped in the course of the last 15 years the structural types of industrial buildings of prefabricated reinforced concrete. These results are largely quoted by technical papers and are internationally well known.

c./ We believe that countries in the course of industrial development might well utilise our experiences in this field.

2./ The conditions of industrialisation.

a./ Hungary possessed a heavy industry before the war, but the shortage of coal and ore deposits hindred its development.

b./ The difficulties of the building industry are determined by the deficiencies of the heavy industry, namely in two respects. Firstly, there is not enough rolled steel. The limited stock of rolled steel and of sheet metal are needed in other fields. Building has to reckon with rolled bars of reduced quality, an inavoidable final product of the steel industry. Meanwhile, should cement production stay below a suitable level, there is enough raw material to raise the output. These facts pinpoint reinforced concrete as the principal material of industrial architecture.

c./ Due to the initial lack of the heavy industry, scores of industrial buildings are needed for it, for power production and for plants of basic material production, with crane equipped shops of large spans, etc. - therefore the tasks are diverse and complicated. There are no means to learn by stages, how to build: easy jobs appear intertwined with complex ones. The situation

is aggravated, as the exigencies of the speedily developing industrialisation are differentiated, even within local aspects. To reach a balanced occupation of all inhabitants from territorial point of view and also a well proportioned progress, industrial centralisation has to be considered, though slightly in the beginning.

d./ The insufficience of timber for the building industry is world wide and increasing. The international market price of lumber is in constant rise. The deficiency compels the methodically planning architect to forego the traditional means of erecting industrial buildings of monolithic structure. To-day, even countries richest in wood turn - later, but just like the others - to the prefabrication of reinforced concrete structures. Finland and Sweden - which are richest in timber production - use precast building methods on a large scale. The U.S.S.R. produced in 1954 about 1,300,000 m3 of industrially prefabricated reinforced concrete elements: this quantity has been raised in 1960 twentyfold, i.e. to 26,000,000 m3.

e./ Considering the building industry of developing countries, an important factor has to be faced, i.e. they are in most cases unprepared to meet the speedily increasing demands: they lack skilled forces for the erection of industrial constructions, there is a general lack of experience.

f./ Prefabrication of reinforced concrete elements are carried out in special plants, or, as we shall detail, on the building site. The more developed stage of prefabrication belongs undoubtedly to the specialised plant, able to handle high qualities of concrete and steel, utilising their ultimate strength. We have to consider simultaneously, that countries in the course of industrial development are in general - due to their relative lag - deficient in funds. Their status becomes somewhat strained in this stage of progress, being compelled by the establishment of a balanced and sufficient basic industry to erect in the same period many industrial plants of most varied kinds. These circumstances strain heavily all resources. Thus, relatively limited resources are left to develop the building industry, which is a means and not the goal of industrialisation. Therefore the strictest economy has to be maintained in this branch: there are no means for large investments, as for fully equipped prefabrication plants with specially designed machinery. Full amortisation of investments for building industry plants are among the longest, as it is widely known. But the prefabrication on the site - contrary to industrialised prefabrication serving the entire building industry - requires only inconsiderable investments. Their initial exigencies are primarily lifting devices of relatively small cost, largely differing from the producing and conveying machinery of industrialised plants.

3./ Prerequisites and realisation of reinforced concrete prefabrication.

a./ To begin with, traditional methods of projecting industrial architecture have to be revised. At the planning of the technological procedure the exigencies of building construction have

to be taken more in consideration. Prefabrication, even on the site, assumes and expects a certain amount of serial production. The possibility of creating identical elements has to be ensured by grouping buildings and by housing different technologies in the same group, as well by the prevailing principles of volume-shaping, concerning the whole plant. Uniting structures, possibly into a single block is - as we have experienced - technologically just as advantageous, because internal delivery becomes shortest and facilitates later regroupments and new technologies. Increased standardisation of structural dimensions is neccessary for the repeated use of building elements. We have to regulate the dimensions of spans, widths and heights of all main structural parts of the buildings, in accordance with previously established principles. In Hungary we achieved by this method of standardisation of frames regularised spans of 6, 9 and 12 metres and this implies the thorough standardisation of roofing structures, i.e., their dimensions. Typification of elements, as a result of standardised dimensioning is the major requirement of prefabrication, which becomes a high grade and economical building method by the single means of serial production.

b./ Judged from the point of view of progressive industrialisation, prefabrication of reinforced concrete elements on the site is an intermediary stage between monolithic construction and industrialised prefabrication. But prefabrication of the site-type is - contrary to the industrialised - very adaptable to different loads: all main parts of load-bearing structures can be cast on the site as they need no transportation. In most cases their weight is under 10 tons. Smaller elements, of 1-2 tons can be produced in the proximity of the site, by a temporarily erected plant, equipped for serial production and preferably roofed, protected from adverse weather.

c./ The mechanisation of the construction has to be twofold. Concrete mixers, woodworking and welding machines, simpler kinds of gantries are neccessary for the aforesaid prefabrication on the site. This small mechanical equipment is of low cost and of short amortisation. Cranes for building purposes are of established types. In the first place we need "universal" cranes - not bound to tracks - on wheels or of the caterpillar type, of 5-10 t capacity. In special cases - for large capacity /f.i. at power-plants/ so-called lifting-towers or rigs convey up to 50 tons. When neccessary, pulley equipped primitive wooden constructions suffice. By this method were erected the prefabricated reinforced concrete shops of the Machine-Tool Factory in Korea.

d./ For connecting the elements lifted into place fully developped methods have been established. Characteristic are the so-called "dry-connections", i.e. those with immediate load-bearing capacity, whereby lifting and placing call for little time, and by rational assembly the demand for lifting devices remains small. For instance, the relatively highly developed building industry of Hungary produces satisfactorily with 40 caterpillar-cranes, though 80 % of our industrial buildings are erected by prefabrication.

e./ Because of serial production, mechanisation, less skilled workers and speeded output, the method described above requires a more carefully scheduled organisation. Construction and design have to be strictly coordinated. One has to reckon with initial difficulties due to the spreading of prefabrication, nevertheless, as is proven by Hungarian experiences, the new method was adapted within one or two years and became an indispensable factor of the building industry.

4./ Advantages of reinforced concrete prefabrication.

a./ As stated above, prefabrication on the building site started as a reasonable stop-gap. Circumstances motivating prefabrication lessen sooner or later, according to the progress of the given countries, but experience proves that this method remains in widespread use. Prefabrication has many advantages compared to monolithic and shuttered construction. These comparisons result in the following conclusions :

b./ With prefabrication, scaffolding becomes superfluous, particularly at levels above 5 metres, for the placing of reinforcement and concrete, Scaffolding requires considerable material, careful execution, skilled labour : it is costly as a method. It is well known that the quality of monolithic reinforced concrete constructions depends mainly on a correct scaffolding which has to be kept up during 40-70 % of the entire construction period. Important scaffolds require especially skilled workers.

c./ With prefabrication the construction of moulds is also advantageous. The average shuttering can be utilised at best 3 to 5 times. Though moulds for prefabrication are somewhat costlier than average shutterings - being sheet-iron covered wooden structures or made of concrete - and are stronger built, but by previously designed construction and by more careful maintenance they last much longer and can be utilised at least 30-50 times. As they are placed at soil level, they are easy to reach, and further, their construction and dismounting does not cause losses. By prefabrication the need for scaffolding and shuttering material decreases 80-90 % compared to monolithic and shuttered methods.

d./ As the placing of reinforcement and of concrete takes place at soil level, the operations and control are easy. The product is of greater precision, consequently the needed tolerances are less.

e./ Due to the former reasons we are in a position to utilise materials of higher quality. The quality of concrete depends mainly on the aggregate, the cement and the water-coefficient, but the circumstances of placing and vibration, i.e. the accessibility of the formwork is by no means secondary. With prefabrication, work and control becomes easy. To indicate the resulting economy, we mention as an example, that the dead load of a main roof truss of 12 m span decreases 50 % when made of concrete of 420 kg/cm2 cube strength, instead of a concrete of 140 kg/cm2 cube strength. This is also of fundamental consequence regarding lifting devices and the dimensions of all load-bearing structures.

f./ With monolithic structures, because of difficult circumstances of erection, we have to adhere to cross-sections of utmost simplicity, while in the course of prefabrication we are enabled to adopt elaborate cross-sections, in the most advantageous and systematic form, as derived from statical computations. Thus, by the building technique we obtain the practical I and T sections, as well as moulded and latticed girders. At the traditional monolithic method the fully quadrangular section is solely employed, in our demonstrated figures the more subtle and latticed forms prevail only. These slender and light structures are also becoming factors of spatial composition, they can compete in many cases with the aspect of steel structures.

g./ The organisation of the prefabricating plant is an easy task and we reach without difficulties an ordered working site and planned output.

h./ By prefabrication, the total number of workers decreases, compared to the traditional methods: this holds good especially to skilled workers. We can dispense largely of carpenters and scaffolders. These, perhaps the most skilled and most valuable men of the building industry should be employed as foremen of prefabricating units.

j./ The constructional time-schedule can be considerably shortened because of a better organisation, simultaneous job-distribution and mechanisation.

k./ Under unfavourable climatic conditions prefabrication diminishes to a certain extent the seasonal character of the building industry, results in a more even employment of workers and indirectly in further cut on time-schedules.

5./ Conclusions :

a./ The constructional principles and the sphere of application of prefabrication are of course still in development. In our opinion, prefabrication calls for adherence to the following two basic principles :

b./ Prefabrication can be applied with success only if there is a possibility for serial production.

c./ We must endeavour to obtain simple connecting-devices for elements of economical cross-sections.

...

6./ Examples of industrial buildings, designed and planned in Hungary for prefabrication on the building-site:

a./ Bale-storage building of a paper-mill. /Fig.I./
By IPARTERV /Planning and Designing Office for Industrial Buildings, Budapest./
Ing. B.Takátsy.

b./ Machine-shop of a shipyard. /Fig.II./
By IPARTERV.
Ing. M.Gnädig.

A most typical system of industrial hall-structures. For gantry-cranes of 24 m, breadth 26,2o m, column distance 9 m, height 11,20 m.

c./ Erection of roofing of a cold-storage plant. /Fig.III./
By IPARTERV.
Arch. L.Csaba, Ing.I.Komlóssy.

Roofing panels on upper flange of main girders; suspended double ceiling carried by lower flange.

d./ Nitrogen fertilizer factory of a chemical combine./Fig.IV.V./
By IPARTERV.
Arch.L.Bajnay, Ing.M.Gnädig.

At the designing of the 24 different industrial buildings of this combine, we succeeded by careful and initial investigation in obtaining a thorough reduction of aggregating elements, to a minimum. By standardisation of hall-structures, the entire combine had been erected with four types of reinforced concrete trusses for roofing, i.e.of 12, 15, 18 and 30 m spans, and by a single kind of roofing-panel of 6 x 1,50 m. Exterior wallings are of light concrete panels of 1,20 x 6,00 m.

e./ Thermal power-plant of 200 MW output. /Fig.VI./
By IPARTERV.
Ing.Gy.Mátrai.

The structure consists of columns of light cross-section and of latticed girders. The lifting of the 30 t elements required special structures of provisional character.

f./ Thermal power-plant. /Fig.VII./
By IPARTERV.
Ing.Gy.Mátrai.

All structural elements of the plant - except the heavily charged intermediary floors and coal-bunkers - had been prefabricated at the site. Prefabrication progressed in periods, due to the great loads of structural elements. The wall-panels had to be erected before the fabrication and lifting of roofing-parts, as all these had to be cast practically on the same spot.

g./ Erection of arched roofing in a machine-tool factory./Fig.VIII./
By IPARTERV.
Ing.L.Garay, Ing.J.Kellner.

Liaisoning arches with tie-rods and latticed beams, we obtained the represented latticed main beams of extraordinary economic features. At the lifting and placing of this element the conditions of stability must be strictly observed.

h./ Workshop of a cable-factory. /Fig.IX./
By IPARTERV.
Ing.Gy.Mátrai, Ing.K.Pászti.

All elements had been prefabricated on the site. Roofing of barrel-vaulted shells of 6 cm, with tie-rods: each shell is of 33,35 x 6,80 m surface and of 57 t weight. Hollow columns of 22,7 tons.

i./ Railway-Car Factory. /Fig.X./
By IPARTERV.
Ing.M.Gnädig.

The multistoried and prefabricated shop with overall floor

charge of 2 t/m2 comprises, as structural parts, light and continuous columns, main girders and floor panels. Liftings were carried out by a caterpillar-crane of 10 t and of a leverage of 18 m.

k./ Universal industrial building. /Fig.XI.XII.XIII./

By IPARTERV.
Arch.L.Bajnay, Ing.M.Gnädig.

A typified structure, suited for all-round utilisation. Columns on a net of 9/9 m. The building is suitable for all functional demands, from storage to the most exacting precision instrument manufacture. It is easily suitable for industrial or in-situ prefabrication. The structure comprises the following elements:

I. Reinforced concrete roof-slab of 1,00 x 3,00 m.
II. Intermediate roof-truss of 9 m /T section/.
III. Roof-truss of 9 m span /or others of 6 or 12 m spans, thus suiting distributions on nets of 6/9 or 9/12 m/.
IV. A single type of column.

l./ Railway-Car Factory in Perambur. /Fig.XIV.XV.XVI./

By IPARTERV.
Ing.L.Garay.

In the State of Madras /Republic of India/ the buildings of the Railway-Car Factory of Perambur had been erected on the basis of designs made in Hungary, utilising prefabrication of reinforced concrete elements, made on the building-site. According to the tender, steel structures had been considered. In the course of international biddings, the Hungarian tender offering reinforced concrete instead of steel was recognised as the most advantageous.

The entire prefabrication was carried out by Indian workers, superintended by two Hungarian engineers. The prefabricating plant was next to the building-site: the upper limit of loads was 10 t. Lifting and jointing of elements was done by two excavating cranes, one of 30 t, the other of 5 t capacity.

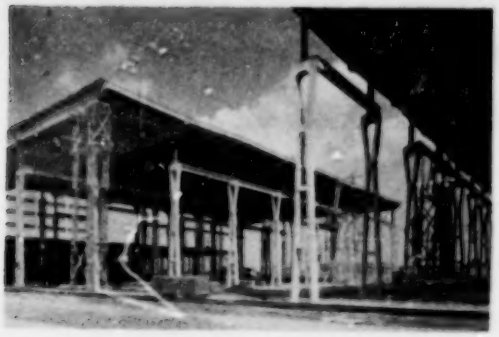

Fig. 1

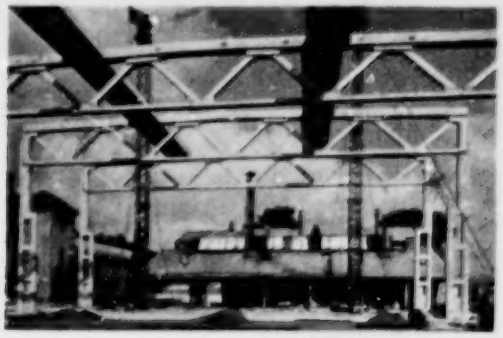

Fig. 2

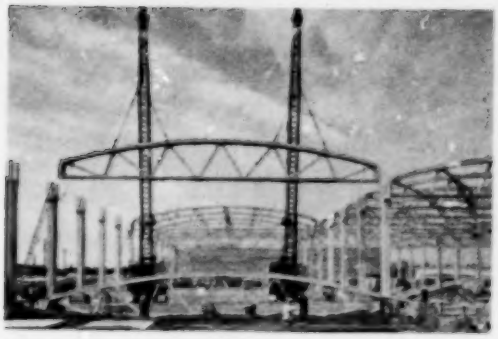

Fig. 3

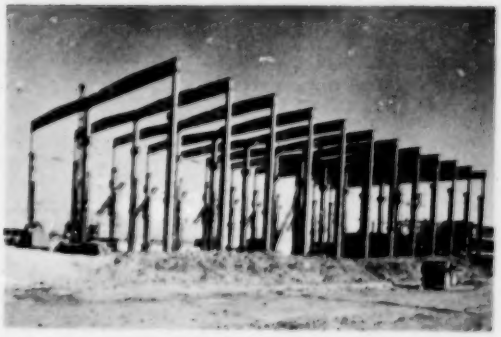

Fig. 4

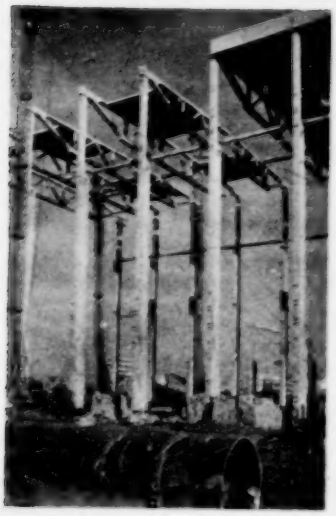

Fig. 5

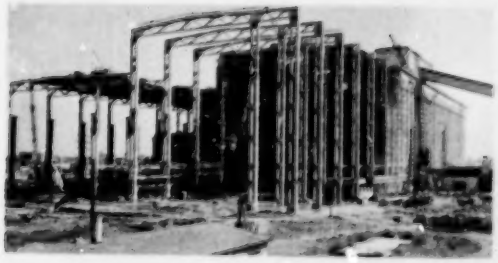

Fig. 6

Fig. 7

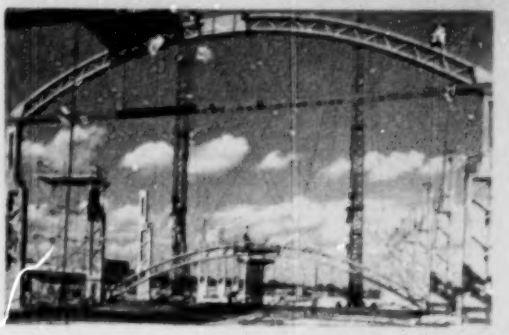

Fig. 8

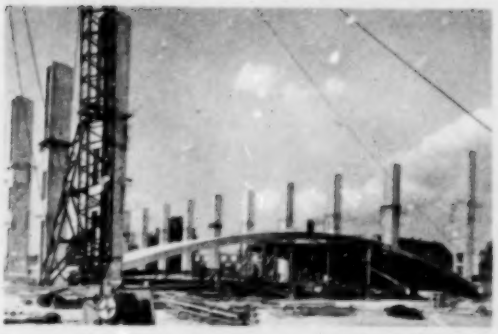

Fig. 9

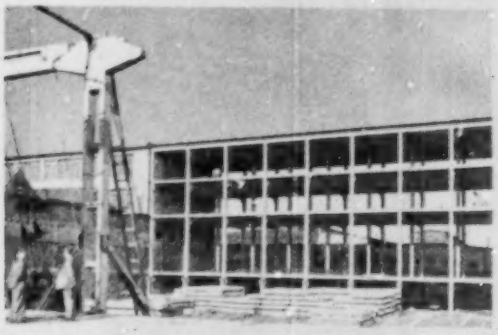

Fig. 10

Fig. 11

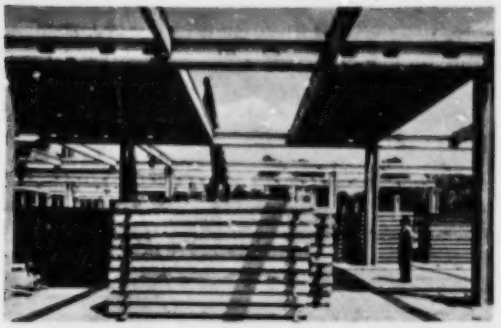

Fig. 12

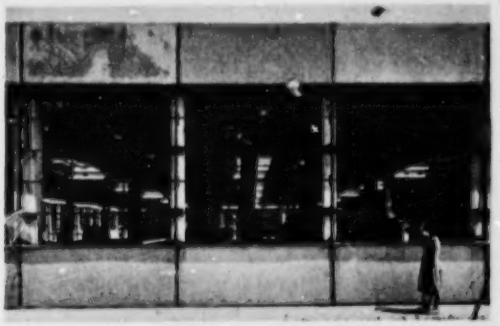

Fig. 13

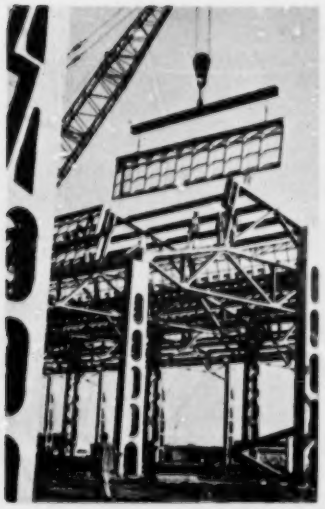

Fig. 14

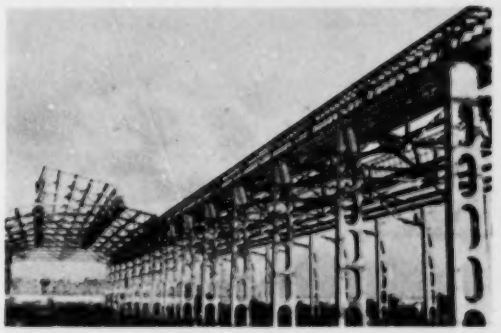

Fig. 15

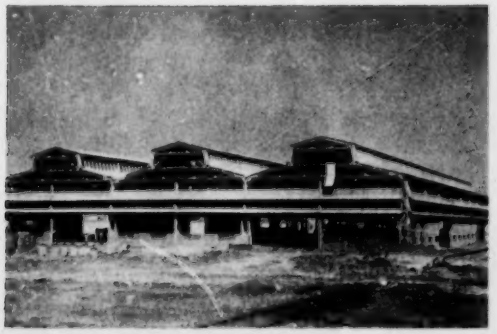

Fig. 16

577 E - Oct. 1962 - 1,600